station BHW-10 was upstream in the main channel, just below the mouth of lagoon #31. Station BHW-11 was located at the distal end of lagoon #37.

Water temperature recorded at these stations ranged from .4 to 30.0°C and air temperatures from 1.3 to 35.0°C (see Tables 136 to 146). Salinity ranged from 13.2 to 28.5 0/00. pH reading varied from slightly acid to basic (6.85 to 8.3). Dissolved oxygen levels were from 0.0 to 13.1 mg/l and percent saturation from 0.0 to 141%. Carbon dioxide values ranged from 0.0 to 11.2 mg/l. Secchi disk depths recorded ranged from one and one half to eleven feet and water depths measured were from four to 26 feet.

B.O.D. values recorded ranged from 0.0 to 6.2 mg/l (see Tables 163 to 169). Slight traces of nitrite nitrogen were observed (<.007 mg/l). Nitrate nitrogen levels ranged from .42 to 2.03 mg/l. Ammonia values were slight 0.0 to 0.4 mg/l. Orthophosphate ranged from 0.0 to .055 mg/l. Detergent concentration detected ranged from .09 to .30 mg/l. Total coliform counts ranged from 11 to 4,600 and fecal coliform from 3.6 to 1,500.

Tidal Creek Survey

Four out of the five tidal creeks selected were sampled during the two year study. Thompson Creek could not be worked into the schedule.

Tuckerton Creek

This water system is located in the lower western portion of Little Egg Harbor Bay. Saline water via Marshelder Channel greatly influences this region. The creek has been extensively developed and is the receiving waters from the upland drainage of

Tuckerton Lake and the effluent (secondary) of the Tuckerton Municipal Utilities Authority (see Table 110).

Seven stations were selected in this tributary. Station TC-0 was situated approximately 500 yards off the mouth. Stations TC-1 (Flashing Light "17"), -3 (near clam house), -5 (across from Hayes BP gas station), -6 (near Gulf Station) and -7 (below lake drainage) were located in the main stem and TC-2 (borrow pit) and -4 (near Daddy Tucker Drive) were in lagoons (see Figure 11).

Water temperatures recorded at these stations ranged from 2.0 to 27.0°C and air temperatures ranged from 2.0 to 27.0°C (see Table 170). Salinity varied from 1.6 to 29.8 0/00. pH readings ranged from slightly acid to basic (6.8 to 9.15). Dissolved oxygen concentrations ranged from 0.0 to 17.1 mg/l and percent saturation from 0.0 to 181 %. Carbon dioxide ranged from 0.0 to 25.5 mg/l. Secchi disk depths recorded ranged from one to six and one-half feet and water depths varied from three to 21 feet.

Parker Run

This tidal creek is located approximately 3 miles north of Tuckerton Creek. Most of the surrounding area remains in a natural state with the exceptions of an upstream site (partial upland and wetlands) along the southern shore and access road leading to a small developed region near the mouth (northern shore).

Six stations were selected in this system. Station PR-0 was located approximately 200 yards off the mouth. Stations PR-1 (Flashing Light "1") and -2 (near Cedar stakes) were situated in the main stem. Stations PR-3 (undeveloped cove), -4 (south branch) and -5 (end) were in the channel of the creek extensions (see Figure 11).

Water temperatures recorded in this system ranged from 3.0 to 24.0°C and air temperatures from 3.0 to 27.0°C (see Table 171). Salinity varied from 3.4 to 28.4 0/00. pH readings ranged from slightly acid to basic (6.8 to 8.72). Dissolved oxygen levels ranged from 0.0 to 16.9 mg/l and percent saturation from 0.0 to 170%. Carbon dioxide values ranged from 0.0 to 12.6 mg/l. Secchi disk depths varied from nine inches to seven feet. Water depth recorded ranged from three to 20 feet.

Westecunk (West) Creek

This tributary situated in Eagleswood Township is located about one mile north of Long Point (channel light #2). The south side of this creek has been extensively developed, however, most of the northern area still remains in a natural state. This system is the receiving waters of all drainage from the town of West Creek as well as the cranberry bogs further west.

Eight stations were selected in this system. Station WC-0 was situated approximately 150 yards off the mouth. Stations WC-1 (Flashing Light "3"), -2 (upstream of Flashing Light "6"), -3 (across from Texaco), -4 (bridge), -5 (adjacent to lagoon), -6 (above public launching ramp) and -7 (below Rt. 9) were all located in the main stream. See Figure 11 for exact locations.

Water temperatures recorded at these stations ranged from -.5 to 28.5°C and air temperatures from -1.5 to 34.0°C (see Table 172). Salinity varied from .4 to 28.6 0/00. pH values ranged from acid to basic (6.2 to 8.4). Dissolved oxygen concentrations ranged from 1.4 to 13.5 mg/l and percent saturation from 30 to 147%. Carbon dioxide levels ranged from 0.0 to 10.2 mg/l.

Secchi disk depths recorded ranged from one and one half to five feet and water depths sampled ranged from three and one-quarter to 10 feet.

Cedar Run

This water system is situated between Mill Creek and Dinner Point Creek. Except for some small homes, docks and an access road constructed along the northern shore, most of the surrounding area remains in a natural state (wetlands).

Six stations were selected in this system. Station CR-0 was situated approximately 600 yards off the mouth. Stations CR-1 to -5 were located in the main stream (see Figure 11).

Water temperatures in this system ranged from 1.0 to 28.3^{o}C and air temperatures from -1.0 to 29.5^{o}C (see Table 173). Salinity varied from 1.5 to 28.3 0/00. pH values ranged from acid to basic (6.0 to 8.3). Dissolved oxygen concentrations ranged from 3.2 to 11.9 mg/l and percent saturation from 45 to 114%. Carbon dioxide levels ranged from 0.0 to 11.7 mg/l. Secchi disk depths recorded ranged from one to four feet and water depths from one to eight feet.

Water Temperature

As was previously mentioned, six thermographs were placed in selected areas to record daily water temperatures over a 45 day period (see Figure 11). However, during the months of July and August and at some stations in September of the first survey period, data was lost due to time spent sending recorders back to the company for calibration. At the end of this first survey period (July, 1973 to February, 1974), the instruments were not pulled out while preparing an interim report. This allowed a complete recording of 12 months of data.

Figure 12 shows monthly mean, standard deviation and ranges of temperature for each station. This also shows that water temperatures during the survey periods, whenever recorded, ranged from $-2.7^{\circ}C$ to $29.4^{\circ}C$. It should also be noted that stations at Long Point, Manahawkin Bridge, and Lower Barnegat Bay during the month of August, 1973, water temperatures had exceeded the ranged on the tape ($>25^{\circ}C$). This was due, as explained above, to a shortage of available instruments calibrated for the high range ($+20$ to $+40^{\circ}C$) and the situation was not corrected until September.

Pesticide - Heavy Metal Analysis

Monthly fish collections showed it was very difficult to collect the same species consistently at selected stations. Even more so to collect a sufficient quantity of any species at a particular station. This was especially evident during the winter and some of the spring collections. Both sampling stations and fish species were selected according to their availability within specific areas.

Oyster toadfish, Opsomus tau, winter flounder, Pseudopleuronectes americanus, summer flounder, Paralichthys dentatus, Atlantic menhaden, Brevoortia tyrannus, white perch, Roccus americanus, and spot, Leiostomus xanthurus were the selected species in all chlorinated hydrocarbons and heavy metal analysis. The oyster toadfish and white perch made up 57 percent of the samples.

Hard clam, Mercenaria merceneria, and the Atlantic ribbed mussel, Modiolus demissus were the two shellfish species selected for the pesticide and heavy metal analysis. As was previously mentioned in the Shellfish Section, the hard clam is the most abundant and is consistently found throughout the bay system. The ribbed mussel, on the other hand, is not commercially important but can be found along the sedge banks (intertidal) of most of the tributaries.

A total of 54 samples were sent to the State of New Jersey Fisheries Laboratory, Lebanon for analysis. Samples were analyzed for the chlorinated hydrocarbons L-BHC, lindane, aldrin, heptachlor, heptachlor epoxide, dieldrin, and DDT and its metabolites. Heavy metal analysis included cadmium, chromium, lead, zinc and mercury.

Results of residue analysis for the chlorinated hydrocarbons found in fish, sediment and shellfish are listed in Table 180 to 184. The data from these analyses are reported in microgram/kilogram (ppb). Results of heavy metal concentrations detected in fish, sediment and shellfish are listed in Tables 185 to 187. All data are reported in milligram/kilogram (ppm).

Slight traces of DDT and its metabolites were detected in 34.6 percent of the fish samples with values ranging up to 17 ppb. Only 20 percent of the shellfish samples showed any traces. None of the other insecticides were detected in either the shellfish or fish meat.

The chlorinated hydrocarbons insecticides, generally speaking are the most toxic to acquatic life. They are known to be very stable compounds and found to be very difficult to control once exposed to the environment. Some of the organochlorine pesticides, including some of their metabolites, are directly toxic at concentrations of less than 1 mg/l.

DDT and its metabolites were detected in 76.6 percent of the sediment samples. Concentrations ranged up to 69 ppb. The only other insecticide observed was heptachlor epoxide; detected in 33.3 percent of the samples.

Results showed that only one sediment sample collected north of the Manahawkin Causeway (RT. 72) had any detectable traces of DDT. The rest of the bay system along with Lagoon System D (Beach Haven West) did not show any pesticide level. All of the tributaries and Beach Haven West complex did show slight traces of DDT. Heptachlor expoxide, when detected, was also found with traces of DDT. The highest levels of DDT were observed at the farthest upstream station of Tuckerton Creek (receiving waters for Tuckerton Lake) and in Parker Run with 69 and 68 ppb, respectively.

The Bureau of Commercial Fisheries, at the Milford, Connecticut laboratory reported that DDT, toxaphine, and aldrin were found to be the most toxic to oyster and clam larvae. Lindane, on the other hand, was almost nontoxic to these larvae, but it inhibited the growth of plankton organisms in their food chain when present in low concentrations.

Smith (1972) reported DDT concentrations ranging from 1.15 to 3.70 ppm resulted in 55 to 98% mortality of winter flounder embryos and vertical deformaties were observed in 2-44% of the hatched larvae. Concentrations of heptachlor, endrin and lindane (0.3-0.4 ppb) killed or immobilized half of the adult commercial brown and pink shrimp (crustaceans) exposed in 48 hour laboratory tests. DDT and dieldrin showed similar effects at 1-6 ppb (Butler & Springer, 1963). In mollusks such as the oyster, Calabrese (1972) reported that DDT at 0.05 ppm caused over 90 percent mortality of oyster larvae and almost completely prevented growth in the survivors.

During Studies of the Upper Barnegat system (1972), DDT and its metabolites were detected in concentrations ranging up to 300 ppb in fish and 2,234 ppb in sediment. Such pesticide levels detected in the fish samples for both estuarine (Upper Barnegat Bay and Little Egg Harbor-Manahawkin Bay) did not exceed FDA's established maximum level in fish for human consumption. However, it would appear that DDT concentrations recorded during this study are in sufficient quantities to have sublethal effects on estuarine organisms.

<u>Heavy Metals</u>

Analylsis of the fish, shellfish and sediment samples showed that all five elements were present. Only slight traces (<0.01 pp~~b~~M) of chromium were detected in the fish and shellfish meat. This was also evident for cadmium with the exception of two readings: .50 pp~~b~~M and .75 pp~~b~~M (detected in the hard clam and ribbed mussel, respectively). The concentrations of lead, zinc and mercury detected in the fish samples were comparable to the levels found in the shellfish samples. (see Table 188).

Results also showed the hard clam to have slightly higher concentrations of zinc and mercury in the meat than the mussel. In fact, the highest levels observed in the edible tissue of both the fish and shellfish was zinc. Such levels were detected in white perch netted in Mill Creek and the Atlantic menhaden collected in the Beach Haven West Lagoon Complex. Hard clams collected in the bottom waters near Main Point, Manahawkin Bay had 20 pp~~b~~M and the ribbed mussels taken from Parker Run was 17 pp~~b~~M.

The heavy metal concentrations in the sediment were found to be much higher than the other samples. Chromium and zinc were detected in all thirty of the mud samples. Out of the five elements lead was found in the highest concentrations. Such concentrations were observed in the subaqueous samples collected at channel light

Flashing Green "21" and Meyer's Pond (197.5 pp~~b~~M), Tuckerton and West Creek's (265 pp~~b~~M), and channel light Flashing Green "53" and Cedar Run (237.5 pp~~b~~M).

Results also showed that the upstream stations in most of the tributaries had higher levels of cadmium than the downstream sites (mouths).

The highest levels of mercury were detected in the bottom samples collected in Dinner Point Creek (2.75 pp~~b~~M), Meyer's Pond and channel light Flashing Green "53" (2.07 pp~~b~~M), Mill Creek (2.03 pp~~b~~M), and Cedar Run (2.01 pp~~b~~M). None of the fish nor shellfish analysis detected any high levels (< .4 pp~~b~~M). In Studies of the Upper Barnegat system (1972), it was reported levels >1 ppm were detected in the bottom waters of Toms River near Pelican Island and in Forked River. Abnormally high levels of mercury are considered to be those exceeding the FDA established maximum of 0.5 ppm for food and 0.005 ppm for water. According to Julian (unpublished paper), hard clams taken from Barnegat Bay were found to have mercury levels ranging from 0.0 to 0.275 mg/kg in edible tissue and 0.0 to 0.3 mg/kg in the shell. Levels detected in the fish, and shellfish ~~and mud~~ are within the limits established by the FDA, however sediments level had exceeded limits (FDA).

Metals reach the marine environment by many ways, including natural weathering as well as municipal and industrial discharges. These metals are, in varying degree, poisonous to humans and marine life, although some of them are essential in trace amounts to humans, as well as other animal life.

Dow and Hurst (1972) have summarized from the literature effects of heavy metals on marine resources:

Cadmium - Extremely toxic to oysters, less toxic to hard clams, and moderately to all other animals. Pringle (1968) reported a 15 week LC50 of 0.1 mg/l and inhibition of shell growth for Crassostrea virginica.

Damage to intestinal tract, kidney and gills of marine fish. It increases the toxicity of other metals.

Lead - Toxic to oyster gonads; also adversely affects hard and soft clam reproduction. Toxic to most enzyme systems. One hundred percent mortality to lobsters in tank. Inhibits one cell algal growth within .5 ppm in water 100 percent lethal in seven days. Oyster larvae killed by 3 ppm levels. Extremely toxic to soft clams above .02 ppm in water.

Zinc - Damage to gills of fish. Toxic to oysters in very small amounts.

Chromium - Not toxic except in large concentrations. This would also vary with valence state, form, pH, synergistic or antagonistic effects from other constituents and the species of organisms involved.

It would appear that some of the heavy metal concentrations recorded in this system are in sufficient quantities to have sub-lethal effects on estuarine organisms.

24 Hour Tidal Survey:

The objective of this study was to seasonably compare temperatures, salinity and dissolved oxygen distribution on an hourly basis for a period of twenty-four hours in a natural verses artificial system. Dinner Point Creek, selected as the natural area, was found to be very shallow (chart depths indicating 1/2 to 4 feet at M.L.W.). However, just below the confluence of the first branch, water depths measured with a fathometer indicated about five feet at low water.

As was previously mentioned, the lagoon within the Beach Haven West complex does not receive any fresh water intrusion other than storm drains or effluent pipes associated with the lagoon type dwellings. The mouth of lagoon #08, situated in System A, was chosen as a station because of its close proximity to the bay area and easily accessible.

Results from this survey can be found in Figures 18 to 29.

In the natural drainage system where shallow depths are evident, it was found that air temperatures directly influence water temperatures. As one would expect, surface and bottom temperatures were similar. In the lagoon complex, this relationship was not evident. Surface and bottom readings varied throughout the survey. Water temperatures were stratified three out of the four periods. The spring survey revealed the greatest stratification; bottom waters remaining consistently colder with a 3.4 to 5.0°C difference over the 24 hour period. On the other hand, the fall survey showed little stratification (0.2°C difference). Water temperatures during the extreme periods (winter and summer) were found to be less stratified, generally evident from early morning till late evening. During the winter extreme, bottom waters were warmer than the surface (0.0 to 2.4°C difference); the summer was just the reverse. Vertical temperature difference ranged from .5 to 2.5°C.

The results indicated that the salinity distribution within the natural area is regulated by tidal flow and seasonal patterns.

During the summer survey, low stream flows produce salinity levels ranging from 22.6 to 27.3 0/00. But during the spring, (high flow period), salinity levels recorded ranged from 19.1 to 27.3 0/00. There was little variation between surface and bottom during the seasonal sampling.

Unlike the cyclic salinity patterns observed in the tidal creek, the salinity distribution in the lagoon area was found generally to be uniform; with little variation. It would appear concentrations are dependent on wind agitation and seasonal dilution. Salinity levels, during the summer survey, ranged from 24.5 to 25.8 0/00; whereas, the spring survey showed concentrations ranging from 24.1 to 24.6 0/00.

On the other hand, dissolved oxygen profiles within the natural area appeared to be regulated according to seasonal conditions. During the summer survey, dissolved oxygen levels were cyclic ranging from 2.0 to 7.5 mg/l. Oxygen levels are normally regulated by tidal flows and periods of photosynthetic activity. It would appear during this period though, that peak levels exist during flood tides; regardless of illumination (see Figure 28). Concentrations below 4.0 mg/l were recorded only during the early morning hours. There was little variation over a twenty-four hour period. Concentrations ranged from 8.0 to 10.1 mg/l with the decline in levels recorded during the early morning.

In the artificial area, oxygen levels were found to be extremely stratified during both the summer and spring surveys. Bottom concentrations during these periods were found to be variable as compared to the surface (0.0 to 8.0 mg/l). This condition was not evident during the other periods. Surface levels during the survey appeared to be regulated by wind agitation and seasonal patterns. Concentrations did not fall below 5.0 mg/l.

The distribution of temperature, salinity, and dissolved oxygen recorded in the artificial system seem to indicate circulation within the area to be very poor at times. The water quality of such an area would be dependent on climatic conditions. Bottom waters were found during the spring and summer surveys to be at times completely void of oxygen. Such anaerobic conditions cannot continuously support a good benthic population. Thermal stratification was evident during three out of the four periods. Such conditions observed in some dredge holes (borrow pits) have been reported to attract over wintering finfish such as the white perch (see Mullica River Report, 1969). More research would be needed to completely evaluate the benefits of stratification within areas for over wintering populations. However, it has been observed that the white perch is one of the more common species found in the artificial systems (see Fish Studies for more details). The fluctuation of anoxic conditions observed during the spring and summer periods within the area would not be considered good water quality criteria for most of your living organisms. Only your more tolerant species could exist (e.g. eels and blue claw crabs).

<u>Isohaline and Isotherm Distribution</u>

Figures 30 to 33 present isohaline and isotherm distribution patterns mapped both on an incoming and falling tide during the summer season.

Discussion

Water temperatures recorded during the two survey periods (July 1973 - February 1974; and June 1974 - May 1975) ranged from -2.7 to 30.5°C. As one would expect, the lowest extremes were observed during the months of January and February; with the latter being the coldest month. The minimum temperature of -2.7°C was recorded in Dinner Point Creek. It is interesting to point out that this was the only system where water temperatures fell below 0.0°C for five consecutive months (December 1974 through April 1975). This tributary is very shallow and found with water depths ranging from 1/2 to four feet at M.L.W. (mean low water). As was reported during the 24 hour tidal survey, water temperatures are greatly affected by air temperatures.

Temperatures below 0.0°C were also recorded at stations WC-0, MC-0 ~~and T-8~~ (-.5°C); MB-9 and T-8 (-1.0°C); and thermograph station located near Long Point (ranging from -2.2 to -1.7°C). Water temperatures at or above 29.5°C (85°F) were observed at the following stations: MB-8, MB-0, MC-0, PP-0, BHW-6 and -10 (29.5°C); DPC-3 and BHW-5 (30.0°C); and MC-6A (30.5°C). The maximum temperature of 30.5°C was recorded in Lagoon #91 (MC-6A), Mill Creek during the month of August.

Temperatures monitored at Beach Haven Inlet (Flashing Light "92") were considered representative of ocean temperatures. The inshore bays, characteristically shallow, are greatly influenced by climatic temperatures. The data shows that seasonal trends were consistent within this system as observed during previous studies conducted within the coastal waters of New Jersey. During the summer, ocean waters are found to be cooler than inshore regions.

However, in September average water temperatures were found to be similar with the exception of Dinner Point Creek (see Figure 34). Temperatures observed in this tributary were somewhat cooler as compared to the other areas. This trend was observed during the periods October to March (1973-74) and September to April (1974-75). Generally, water temperatures gradually decreased at the end of September through to December. Whereas in January and February, severe cold conditions caused abrupt changes in water temperatures. Mean temperatures in March steadily increased into the warmer months.

Water temperatures along the western portion of the bay are greatly influenced from the tributary drainages (see Figure 34).

The bay area showed very little vertical temperature difference; generally not differing more than .6°C. The only exception was a difference of 1.3°C recorded during September 1973. Typically, during the warmer months, water temperatures tended to increase from Beach Haven Inlet to the Manahawkin Causeway. During the winter period, water temperatures in the bay area were less stratified.

Thermal stratification was evident during both the summer and winter periods in some of the artificial systems. Late spring and summer temperatures were found to be much more stratified with bottom temperatures showing more variability than the surfce e.g. station BHW-2, -3, -6, -8 and MC-5. The bottom waters of station BHW-6 was observed with highest vertical temperature difference of 16.7°C. Stations BHW-3, -6 and -8 showed that stratification was not limited to the distal end of a lagoon.

Not all stations within the artificial complex were found to be thermally stratified. Only station BHW-6, the farthest upstream in System B, was consistenly stratified throughout the study. This was also evident in the channel of Mill Creek, but to a lesser degree.

Salinity patterns were similar to water temperature stratification observed in Mill Creek insofar as the effects of fresh water intrusion in this system. It is interesting to point out, that the bottom waters of lagoon stations MC-4 and MC-5 were found to have salinity levels greater than the downstream channel station MC-3.

In the lagoon complex, vertical stratification was less pronounced but nevertheless evident. Bottom levels measured in some lagoons were also found to be higher than the downstream station, e.g. station BHW-2, -3, -6 and -8.

In the bay, salinity levels recorded for the surface and bottom waters were found to be similar; vertical differences never exceeding 2.1 0/00. Maximum salinity levels were recorded at Beach Haven Inlet (32.0 0/00). This station had a range of 27.5 to 32.0 0/00. The salinity differences from Beach Haven Inlet to the Manahawkin Causeway (Rt. 72) was never more than 8.9 0/00. Except for one reading of 19.8 0/00 levels never fell below 20.0 0/00.

Generally, average levels between tidal stages within the artificial areas were similar (see Figure 35). Overall averages from June through to December ranged from 24 to 25.6 0/00 with the exception in September, levels were around 23.0 0/00. From mid-winter through spring, when climatic conditions influence tidal dilution, average levels fell between 21.0 to 22.0 0/00.

Average salinity levels were higher in Dinner Point Creek as compared to Mill Creek. However, average levels were somewhat higher in the artificial areas than the natural system. Station DPC-3, the farthest upstream in Dinner Point Creek was found to have the greatest salinity fluctuation (3.3 to 26.2 0/00). Station MC-6, the farthest upstream station in Mill Creek was observed to have a range of .3 to 14.7 0/00.

Oxygen levels recorded in the artificial systems were found at times, as the water temperatures, to be extremely stratified and variable. This condition was not evident at those stations situated at the mouths of the lagoon complex (e.g. stations BHW-1 and -9).

All of the submerged waters within the artificial system (excluding stations BHW-1, -5 and -9) were found at some period of the survey to have oxygen levels less than 3.0 mg/l. Such concentrations are critical for many living organisms. This also was true for stations MC-4 and -5 located in Mill Creek.

Anoxic conditions (<1.0 mg/l within the lagoon complex) were found at depths ranging from seven to 26 feet. Almost 50% of these readings were observed at water depths over 15 feet (depths usually observed in the channel). Depths less than 15 feet were found at the distal end of the lagoons. Station BHW-6, in System B was found only during the months of October and November with oxygen levels above 4.0 mg/l. The rest of the months, bottom waters were void of oxygen.

In the bay, some stratification was evident but to a lesser degree. Surface oxygen levels were found to vary. Levels recorded in the lower bay area were generally lower than concentrations observed in the upper regions. This was probably attributed to seasonal trends and/or climatic conditions. Concentrations were never detected below 5.4 mg/l.

In the natural area, oxygen levels below 5.0 mg/l were measured during the studies. This was very evident during the summer months and to a lesser degree in the fall. It is interesting to note that levels as low as 2.8 mg/l were observed during the fall sampling of the first study period. Normally, oxygen levels during this time of the year are found to be around 9.0 mg/l. The data shows that the farthest upstream station (DPC-3) was observed with reduced levels throughout the year. The second study again showed reduced oxygen levels in this system. Except for stations DPC-3 (farthest upstream) the data suggests reduced levels to be consistent with ebbing tides or low water conditions. It would appear from the reduced levels observed at this station, the area during certain periods of the season to be stressed.

Mill Creek, being deeper, only once was the bottom waters within the main channel found with levels below 3.0 mg/l. However, stations MC-4 (undeveloped) and MC-5 (developed lagoons), both located within Mill Creek system, were found with oxygen levels greatly stratified. Bottom waters were generally found greatly reduced or void of oxygen. Surface levels during the summer period were found to be extremely high (15.0 mg/l). Such conditions would suggest algae problems.

High surface dissolved oxygen levels were also observed in Tuckerton Creek and Parker Run. Oxygen levels of 15.0 mg/l or more were observed in Tuckerton Creek at stations TC-2 (16.2), -4 (16.8) and -5 (17.1) during October. In Parker Run, at station PR-4, high levels were observed in February (15.9) and April (16.8). There were other stations exhibiting unusual high surface oxygen levels as compared to the time of the season; however, such concentrations did not exceed 15.0 mg/l. Such concentrations were observed at stations TC-4 (14.4), -5 (10.3), -6 (13.3) during July and in Parker Run at stations PR-3 (12.6 & 13.1), -4 (14.5) and -5 (14.9 & 12.2) during April. Anoxic conditions were also observed in some of the bottom waters of these two tributaries during the summer period (e.g. stations TC-2, -6, PR-4 and -5).

The waters of Westecunk Creek and Cedar Run were also found to be stratified. Reduced oxygen levels, evident primarily during the warmer months, were limited to the upstream stations of both tributaries (e.g. stations WC-3, -4, -5 and CR-2 and -3).

All pH levels measured in the bay were near or basic. There was little difference between surface and bottom readings. Maximum levels recorded in the bay were found in the waters at stations MB-1 (8.65) during August, MB-5 (8.5) and T-2 (10.0) during October and MB-9 (8.5) during October and May.

In the natural area, pH readings ranged from slightly acid to basic with the exception of station DPC-3, where levels were found to vary from acid to near basic.

In the artificial system (lagoons), pH levels ranged from slightly acid to basic. Readings above 8.5 were only recorded in Mill Creek at stations MC-3 (8.7), -4 (8.5, 8.8 and 8.9) and -5 (8.5 & 8.9). Except for station MC-4 with a reading of 8.8 recorded in July, all the other values were measured during August. Mill Creek was also found with the lowest pH of 5.7, recorded at station T-18.

Readings above 8.5 were also observed in Tuckerton Creek and Parker Run. The highest recordings measured in the tributaries during the two study periods were at station TC-6 (9.0 and 9.15) during the month of July. Other readings taken during this period were measured at station TC-2 (8.55) and TC-5 (8.65). In Parker Run, during April, pH values of 8.72 and 8.5 were taken at station PR-4 and -5 respectfully.

Average surface carbon dioxide concentrations were lowest in the bay area as compared to the other systems (see Figure 37). Both Mill Creek and Beach Haven West were found to be similar, insofar as levels were lowest during the summer months followed by a slight increase going into the winter months. A gradual decrease in February was followed by an abrupt increase in April but quickly decreased going into May. In Dinner Point Creek average levels were found to the reverse. During the summer, carbon dioxide gradually increased up until August and gradually decreased going into the winter period. From February through June, levels remain very similar. The highest concentration was detected at station DPC-2A (36.3 mg/l).

Average secchi disk depths were found to higher in the artificial system as compared to the natural areas. Except for maximum depths recorded at stations BHW-2 (8'6"), -7 (11') and -8 (10') during the first survey, depths never exceeded 6'6" during the second period. Dinner Point Creek being shallower with a soft mud bottom, was found at times to be extremely turbid. Light penetration never exceeded 4'6". Average readings ranged from 1 to 2 feet.

Transparency values generally were high in the bay. Maximum depths or areas of greatest light penetration were observed in Beach Haven Inlet at ten feet (MB-1) and Sandy Island at 9'6" (MB-11A).

Biochemical Oxygen Demand (B.O.D.) values recorded during the two study periods were found to be good. Generallly, average B.O.D. levels were high during the summer period but gradually dropped going into the fall (see Figure 38). However, during November, high readings caused an abrupt increase followed by a decrease going into the spring. It has been suggested that a clear stream or harbor should not have a B.O.D. of greater than 4.0 ppm, (Lackey, 1958). Only during the second study period did concentrations exceed 4 mg/l.

In the artificial systems, B.O.D. values generally were found to be higher than the natural area. The drainages (main stem) of Mill Creek and Dinner Point Creek had similar average levels. However, station MC-6A (lagoon #91) located in Mill Creek, was found during November to have a B.O.D. value >12.0 mg/l. On the other hand neither Dinner Point Creek nor the bay area were found with concentrations exceeding 6.0 mg/l.

Nitrite nitrogen was analyzed only two months during the two studies. Concentrations detected were negligible (.036 mg/l was the highest level detected).

The nitrate values recorded during the first survey period (July '73 to February, 1974) were found to be extremely high. Such unusually high readings were considered unrealistic and were omitted from the data. Data collected during the second survey showed Dinner Point Creek to have higher nitrate levels than the artificial systems. Peak levels (.97-3.98 mg/l) were observed at the farthest upstream station, DPC-3. Concentrations were found to be consistently higher at this station. The data also showed average levels recorded in Mill Creek to be slightly lower than the bay. The highest level observed in the Bay was .94 mg/l recorded at station MB-9.

Ammonia levels, when detected, were found to be very slight (0.0 to .4 mg/l). During the first survey period, traces were found to be similar. The only exception was during the month of January (0.0 - .28 mg/l). Concentrations were found to be lower during the second period as compared to the initial survey (0.0 - 0.16 mg/l). It was during the second study that no traces of ammonia were detected in the bay area. The only levels observed in Dinner Point Creek were detected at station DPC-3. With the exception of one reading (<.01), the artificial systems did not show any traces during the second period. In Mill Creek, only the stations MC-3, -4 and -5 located above the sewerage treatment facility did show traces.

Small amounts of the soluble form of phosphate were detected (0.0 - .17 mg/l). During the first survey period, average levels were highest in September. The second period showed maximum levels were during the month of November. It was also during this month that the highest level of .17 mg/l was recorded at station MB-7.

Detergent (MBAS) levels detected during the 1973-74 survey were all <.2 mg/l. Because of such low levels it was decided during 1974-75 period to only survey a few selected stations. During this second survey period, concentrations were found to range from 0.0 to .34 mg/l. The effect of detergent concentrations of .5 ppm of fish life is believed to be minimal (Eisler, 1965).

Detergent values recorded were highest during the months of September, October and November. It was during the month of

October that the highest reading of .34 mg/l was recorded at station DPC-3.

As was reported in the Shellfisheries Section, the waters of the Manahawkin Bay-Little Egg Harbor system were found to be very productive for both the commercial and recreational clammer (also see Use Study). The State of New Jersey Health Department, Bureau of Shellfish Control, located at Leeds Point, Absecon, routinely inspects and analyzes the water quality of New Jersey's coastal bays and waters. Contamination is determined by the number of coliform bacterial counts. The total coliform median MPN (most probable number) of the water does not exceed 70 per 100 ml, and not more than 10% of the samples ordinarily exceeds MPN of 230 per 100 ml for a five-tube decimal dilution test. However, there are other factors that also must be taken into consideration before a particular area is classified. It is equally important to conduct a hydrographic study of an area and if necessary to also include shoreline investigations. Even if the bacterial counts may be considered good, an area could be closed if other factors prove to be a danger to public health (Eisle, phone communication).

Naturally, overlying waters of shellfish areas are classified by standards developed by the U.S. Public Health Service and member States of the Cooperative Program, for Certification of Interstate Shellfish Shippers. The accepted standards are:

0-70 Coliform bacteria per 100 ml of water - Clean

71-700 Coliform per 100 ml of water - Moderately Contaminated

Over 700 Coliform per 100 ml of water - Grossly Contaminated

Tables 174 to 179 lists coliform density in MPN/100 ml (most probable Number per 100 milliliters). Results indicate that coliform counts did exceed 700 in the Manahawkin Bay-Little Egg Harbor System (see Tables 188A & 188B).

In the bay areas both total and fecal coliform counts were low except for one total coliform count reading (750) observed at station MB-5 during August. However, in the natural area (Dinner Point Creek drainage) several high total coliform readings were observed during the two survey periods (930 to 4,600). Readings were consistently high at station DPC-3 during the summer and fall period. An attempt was made to try to determine what was the contributing source of pollution. Unfortunately only one successful run was made to establish a fecal coliform-streptococcus ratio. No conclusive interruption could be made at this point. This particular test was conducted during a period of low readings (total coliform counts). However, the results have suggested that there are traces of human influence. This area is also reported to support a good wildlife population. The low dissolved oxygen concentrations that have been monitored throughout the survey at this station may further indicate stress conditions. Before any conclusions on whether present upland development could be a source would necessitate further research.

In Mill Creek, high tidal coliform counts were observed during September (930 - 4,600) and once during November (1,100). The maximum value of 4,600 was recorded at station MC-5 (lagoon 98). As was previously mentioned, this system is the receiving waters for the treated effluent (secondary) of the Beach Haven West Sewage Treatment Facility and drainage from Manahawkin Lake. During September, high readings were observed both below and above treatment plant and as well from upland drainage.

High fecal coliform counts were also recorded periodically in this drainage (91-2,400). The frequency of readings were greater as compared to total coliform counts. The fecal streptococcus tests, although limited, did suggest both human and animal influence.

Several high total coliform counts were measured in the artificial complex (930-4,600). Readings were found to be very sporadic. It is most probable, as suggested by fecal streptococcus tests, that the dock population utilizing these lagoons were the major factor.

Summary

The Manahawkin Bay-Little Egg Harbor System study was conducted within the following boundary lines: the farthest point of Manahawkin Bay indicated by a line from the mouth of Gunning River across the Intracoastal Waterway to Harvey Cedars; the southern portion indicated by a line across Beach Haven Inlet from Shooting Thorofare to the southern tip of Long Beach Island.

The survey concentrated on Little Egg Harbor Bay, Manahawkin Bay, drainages of Dinner Point Creek, Meyer's Pond, Popular Point, Mill Creek and Beach Haven West Lagoon Complex. Also included were tributaries such as Tuckerton Creek, Parker Run, Westecunk (West) Creek and Cedar Run. Water acreage for these areas surveyed were a total of 26,247.

The bay volume consisted of 28,889,370,202 gallons with a mean depth of 3.5 feet and a shoreline length of 75.8 statute miles.

It was estimated that a total of 15,922 acres of wetlands are located within the study area. Portions of this acreage that are State owned are the Great Bay Boulevard Wildlife Management Area (3,789 acres) and Manahawkin Wildlife Management Area (965 acres). Also included are Federally owned and/or managed property such as the wetlands extending south of Mill Creek (3,800 acres) and the Gunning River Refuge (3,506 acres) which is adjacent to the Manahawkin Tract.

According to the Wetlands Inventory by the New Jersey Department of Environmental Protection, twelve plant species have been identified in the study area: _Spartina alterniflora_ (tall and short salt marsh cordgrass), _Spartina patens_ (salt meadow cordgrass), _Iva_

Frutescens (hightide bush), *Baccharis halimifolia* (sea myrtle), *Distichlis spicata* (spike grass), *Juncus gerardi* (black grass), *Parricum virgatum* (switch grass), *Scirpus olveyi* (olvey's bulrush), *Phragmites communis* (common reed), *Typha spp.* (cattail), and *Spartina cynosuroides* (salt reed grass).

There has been very little development in the study area as compared to the remainder of Ocean County. Major development (2,139 acres) has been restricted primarily to the Manahawkin and Tuckerton area.

A total of sixteen lagoon systems have been identified. This would account for 2,061.6 acres of development resulting in 48,000 feet of developed shoreline.

This water systems is one of the cleanest and most productive estuaries along the New Jersey coast. Of the 34,789 acres between Beach Haven Inlet and Barnegat Inlet, only 2,480 acres are condemned. Commercially important shellfish found within the system include the hard clams, *Mercenaria mercenaria*; bay scallop, *Argopectin irradians*; and blue mussel, *Mytilus edulis*. Of these, the hard clams is the most important. Because of its abundance, the hard clam supports more shellfishermen than any other shellfish within this system. The soft clam, *Mya arenaria* and eastern oyster, *Crossoptrea virginica* are also found within this system but are not of commercial importance.

Water temperatures ranged from -2.7 to 30.5°C. The data shows that seasonal trends were consistent within this system as observed during previous studies conducted within the coastal waters of New Jersey. The lowest extremes were recorded during the months of January and February and the highest extremes during

August. The bay area showed very little vertical temperature difference; generally not differing more than .6°C. Thermal stratification was evident during both the summer and winter periods in some of the artificial systems. Some bottom waters had a temperature difference of 16.7°C.

Salinity ranged from .3 to 32.0 0/00 with the highest averages observed during the fall months. In the bay, salinity levels recorded for the surface and bottom water were similar; vertical differences never exceeding 2.1 0/00. The salinity difference from Beach Haven Inlet to the Manahawkin Causeway was never more than 8.9 0/00. Except for one reading of 19.8 0/00, levels never fell below 20.0 0/00.

In the lagoon complex, vertical stratification was less pronounced but nevertheless evident. Bottom levels measured in some lagoons were also found to be higher than the downstream station.

The maximum salinity fluctuation recorded in the surface waters at any one station was station DPC-3, the farthest upstream sampling location in Dinner Point (3.3 to 26.2 0/00).

Dissolved oxygen levels ranged from 0.0 to 17.1 mg/l. In the bay, some stratification was evident but to a lesser degree. Concentrations were never detected below 5.4 mg/l. However, in Dinner Point, levels below 5.0 mg/l were measured during the summer month and to a lesser degree in the fall. Reduced oxygen levels were consistently observed at station DPC-3 (farthest upstream) during a falling tide.

All of the submerged waters within the artificial systems (excluding BHW-1, -5 and -9) were found at some period of the survey to have oxygen levels less than 3.0 mg/l. Anoxic conditions (<1 mg/l) were found at depths ranging from seven to 26 feet.

Nearly 50% of these readings were observed at water depths over 15 feet (depths usually observed in the channel). The bottom waters of station BHW-6 in System B was found only during the months of October and November to show oxygen levels above 4.0 mg/l.

Mill Creek, on the other hand, only once was the bottom waters within the main channel found with levels below 3.0 mg/l. Lagoon stations MC-4 and MC-5, both located in this tributary, were generally observed with bottom waters greatly reduced or void of oxygen. During the summer period, surface levels were found to be extremely high (15.0 mg/l).

High surface levels (15.0 mg/l or more) were also observed in Tucckerton Creek and Parker Run during various portion of the survey.

pH readings throughout the Manahawkin Bay-Little Egg Harbor system ranged from 5.7 to 10.0. Normally readings did not go over 8.5 except during the months of July and August.

"Free" carbon dioxide levels measured, ranged from 0.0 to 36.3 mg/l. Generally average levels for the system were highest during the warmer months and minimal during the winter.

Secchi disk depths ranged from three inches to eleven feet. Transparency values were generally high in the bay. Average readings were found to be higher in the artificial system as compared to the natural area (Dinner Point Creek). Dinner Point Creek being shallower with a soft mud bottom, was found at times to be extremely turbid. Light penetration never exceeded 4'6".

Biochemical Oxygen Demand (B.O.D.) values measured during the two study periods were found to be good. Generally, average levels were high during the summer period but gradually dropped going into the fall. Levels ranged from 0.0 to 12.0 mg/l.

Nitrite nitrogen (.036 mg/l maximum) and ammonia levels (0.0 to .4 mg/l) were found to be very slight.

Nitrate levels recorded during the second survey, ranged from 0.0 to 3.98 mg/l. High concentrations (.97 to 3.98 mg/l) were consistently measured in Dinner Point Creek (station DPC-3). Generally, levels in the system were found to be higher during the fall rather than the winter season.

Small concentrations of orthophosphate were detected (0.0 - .17 mg/l). The highest level being recorded in the bay at station MB-7.

Slight traces of detergent were detected within this system ranging from .0 to .34 mg/l.

Bacterial monitoring program showed that total coliforms counts ranged from <3 to 4,600 MPN/100 ml and fecal coliform from <3 to 2,400 MPN. In the bay areas both total and fecal coliform were generally low. However, high coliform counts of 4,600 were observed in Dinner Point Creek, Mill Creek and in the Lagoon Complex. Before any conclusion can be made to determine whether animal or human influence may be a contributing factor; would necessitate further research.

Results of residue analysis for the chlorinated hydrocarbon showed slight traces of DDT and its metabolites were detected in 34.6% of the fish samples with values ranging up to 17 ppb. Only 20% of the shellfish meat showed any traces. None of the other insecticides was detected in either fish or shellfish meat.

DDT and its metabolites were detected in 76.6% of the sediment samples. Concentrations ranged up 69 ppb. The only other insecticide observed was heptachlor epoxide; detected in 33.3% of the samples.

Analysis of fish, shellfish and sediment samples showed that all five element were present. Only slight traces (<0.01 pp~~b~~m) of chromium and cadmium were detected in the fish meat. Lead ranged from 0.0 to 6.1 pp~~b~~m, zinc from 5.65 to 16.85 pp~~b~~m and mercury from 0.0 to 0.4 pp~~b~~m. Only slight traces of chromium (<0.01 pp~~b~~m) were as well detected in the shellfish samples. Cadmium ranged from <0.01 to 0.75 pp~~b~~m; lead ranged from 0.0 to 5.7 pp~~b~~m; zinc ranged 2.5 to 20.0 pp~~b~~m and mercury from 0.0 to 0.29 pp~~b~~m.

In the sediment samples; cadmium ranged from 0.0 to 3.0 pp~~b~~m; chromium from 3.0 to 50.0 pp~~b~~m; lead from 0.0 to 297.5 pp~~b~~m; zinc from 2.0 to 66.6 pp~~b~~m and mercury from 0.0 to 2.75 pp~~b~~m.

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Phase III, Use Study

by

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ABSTRACT

The Use Study of the Manahawkin Bay - Little Egg Harbor System was designed to determine the ways in which the estuarine system is used, the estimated total man-days of activity for each major type of user-group, expenditure estimates for various user-groups, and an estimated resource harvest for the entire system.

Aerial surveys, bag and creel surveys, and expenditure surveys were the three integrated survey methods utilized to obtain data for the above determinations.

For the eight month study period, July 1973 to February 1974, resultant tabulations show that an estimated 158,269 man-days of activity had occurred within the study area and an estimated 446,754 fish (including crabs), 14,365,902 shellfish and 306 waterfowl were harvested at an estimated cost to those involved of $835,222.55.

During a second sampling period from June 1974 to May 1975, excluding November and December 1974, an estimated 230,326 man-days of activity occurred within the study area with an estimated total harvest of over 450,000 fish (including crabs) and over 19 million hard clams. An estimated $2,206,033.04 were spent by those persons using the study area during this time period.

INTRODUCTION

The Use Study of the Manahawkin Bay - Little Egg Harbor System is an attempt to estimate the extent and types of all major estuarine activities. Under the continuing Estuarine Evaluation Project, the Bureau of Fisheries conducts an intensive survey and inventory of all major New Jersey estuaries, usually allocating an entire year for each system. Manahawkin Bay - Little Egg Harbor represents the fifth major estuarine system to be studied under this continuing project.

The study area covers tidal waters and associated marshlands with the upland treeline serving as an easily recognizable boundary line. It is within these areas that most activities effecting estuarine resources are conducted. Covering the entire watershed was prohibitive due to insufficient manpower. The northern boundary of this study area was drawn at Sandy Island in Barnegat Bay midway between the Barnegat National Wildlife Refuge on its West and Harvey Cedars on its East. Little Egg Harbor Inlet and the North side of Great Bay Boulevard were the southern limits to the survey area. Activities performed on the bay side of Long Beach Island such as bank fishing were included whereas those activities such as surf fishing on the ocean side of the Island were not considered. (see Figure 39 for above specified locations).

The survey attempted to determine how the estuary is used by man, both commercially and recreationally, the different types of user-groups*, an estimated total man-days* for each activity, total resource harvest, and total expenditures by the different user-groups.

*Consult Definitions Section for an explanation of these terms.

There is also presented a comparison between the total use picture of the lagoon community of Beach Haven West and the adjacent natural marshland.

Initially, an eight month study of the Manahawkin Bay - Little Egg Harbor System was conducted from July 1, 1973 to February 28, 1974. This was followed by a similar, twelve month study of the same area from June 1, 1974 to May 31, 1975. The three month interim was due to administrative scheduling for report writing. This report presents the results of twenty months of field work covering both study periods.

ACKNOWLEDGEMENTS

The Use Study of Manahawkin Bay - Little Egg Harbor was initiated by Assistant Fisheries Biologist Bruce A. Halgren. The study continued under his supervision throughout the eight month period (July 1973 to February 1974) and also during seven months of the twelve month period (June 1974 to January 1975). Upon his transfer to a different project, I assumed leadership of this phase of the Estuarine Evaluation Project.

Fisheries Worker Russell Tilton performed the greatest part of the field work throughout the twenty months of sampling. His enthusiasm and dedication to the Use Study field sampling is most appreciated.

Principal Fisheries Biologist Paul E. Harner is also acknowledged for his supervisory assistance and recommendations.

The assistance with field work from other lab personnel is also greatly appreciated. Those of assistance include: Senior Fisheries

Workers Jeffrey Carlson and Keith Lockwood, Fisheries Workers Barry Preim and William Andrews, and Summer Worker Frederick Bubeck.

East Little Egg Harbor - See Figure 39: Section 3. That portion of the study area bordered on the south by Little Egg Inlet, on the west by a line from Tucker Island sand bar to Goosebar Sedge to East Sedge Island to Shelter Island, on the north by a line from Long Point to Marshelder Islands and on the east by Long Beach Island.

East Lower Manahawkin Bay - See Figure 39: Section 4. That portion of the study area bordered on the south by a line from Long Point to the Marshelder Islands, on the north by State Highway 72, on the east by Long Beach Island and on the west by a line from Shelter Island to Cedar Bonnet Island.

East Upper Manahawkin Bay - See Figure 39: Section 5. That portion of the study area bordered on the south by State Highway 72, on the north by a line from Dipper Point to Maiden Land in the Borough of Harvey Cedars, on the west by a line from Cedar Bonnet Island to Sandy Island and on the east by Long Beach Island.

Hours per Angler - The average number of hours spent per fishing trip.

Man-day - An indeterminant length of time an individual spends on the study area during any day.

Natural Marsh - See Figure 39: Section 5. That portion of section 1 of the study area that is bordered by Mill Creek on the north, Meyers Pond Creek on the south and the upland tree line to the west. Boats involved in activities in very close proximity, (within 10 to 20 feet) to the shoreline of the marsh were also included in this section.

Others - Any activity that was either unknown or which did not fit in the listed categories of major user-groups. This would inlcude, but is not limited to, sightseers, bird watchers, hikers, or other naturalists, picnickers and non-fishermen with groups of bank fishermen.

Shell Fishing - Any individual harvesting clams, oysters, scallops or mussels.

User-Group - A major activity category and its participants, such as bank fishermen, boat fishermen, etc.

West Little Egg Harbor - See Figure 39: Section 2. That portion of the study area bordered on the north by a line from Long Point to the Marshelder Islands, on the south by Great Bay Boulevard, on the west by the upland tree line and on the east by East Little Egg Harbor as defined above.

West Lower Manahawkin Bay - See Figure 39: Section 1. That portion of the study area bordered on the north by State Highway 72, on the south by a line from Long Point to the Marshelder Islands, on the west by the upland tree line and on the east by East Lower Manahawkin Bay as defined above.

West Upper Manahawkin Bay - See Figure 39: Section 6. That portion of the study area bordered on the south by State Highway 72, on the north by a line from Dipper Point to Maiden Lane in the Borough of Harvey Cedars, on the west by the upland tree line and on the east by East Upper Manahawkin Bay as defined above.

The following sub-section of this definition list also appears in the above mentioned Miscellaneous Report No. 14M and includes those species of fish and shellfish harvested by sport and commercial fishermen interviewed in the study area.

Common Name	Scientific Name
Bay Scallop	*Argopecten irradians*
Blackfish (Tautog)	*Tautoga onitis*
Blowfish (Northern puffer)	*Sphaeroides maculatus*
Blue crab (Blue claws)	*Callinectes sapidus*
Bluefish	*Pomatomus saltatrix*
Eel (American eel)	*Anguilla rostrata*
Flounder (Winter flounder)	*Pseudopleuronectes americanus*
Fluke (Summer flounder)	*Paralichthys dentatus*
Hard clam	*Mercenaria mercenaria*
Kingfish (Northern kingfish)	*Menticirrhus saxatilis*
Northern searobin	*Prionotus carolinus*
Oyster toadfish	*Opsanus tau*
Porgy (Scup)	*Stenotomus chrysops*
Sea bass (Black sea bass)	*Centropristes striatus*
Sandbar shark	*Carcharhinus milberti*

Common Name	Scientific Name
Smooth dogfish	*Mustelus canis*
Spot	*Leiostomus xanthurus*
Striped bass	*Morone saxatilis*
Weakfish	*Cynoscion regalis*
White perch	*Morone americana*

METHODS

Three integrated methods were employed to accomplish the objectives of the Use Study. Aerial surveys provided the data for monthly estimates of total man-days of activity within the study area. Bag and Creel surveys yielded total harvest estimates for the study area. Expenditure surveys enabled the calculation of per-trip expenditures and total expenditures for the different user-groups. In addition, a survey was initiated in June 1974, to determine the geographical origin of the different user-groups in the study area. A detailed presentation of the methods employed is given below.

I. AERIAL SURVEY

Three aerial surveys were scheduled weekly, two on weekdays and one on a weekend day or holiday. The days for scheduling of flights were randomly chosen. Due to the greater recreational pressure on weekend days, these data were completed separately from weekdays. Holiday flight data were treated as weekend days due to similar recreational pressure.

During the months of January and February of both study periods, sampling frequency was reduced to one weekday flight and one weekend flight per week to economize during minimal activity periods. This practice went into effect after the last day of duck hunting season in January. Also, there were no aerial surveys conducted during November 1974 and December 1974 when monies allocated to this study were temporarily exhausted.

All flights were randomly scheduled between the hours of 10:00 A.M. and 3:00 P.M., considered the greatest activity period of the day (Briggs, 1962). It should be realized that the estimated total man-days of activity will be a low estimate since no count is taken of user-groups utilizing the study area only during the early morning and late afternoon hours. No adjustments were made to monthly estimates for this fraction.

The survey area was divided into eight sections: East and West Little Egg Harbor, East and West Lower Manahawkin Bay, East and West Upper Manahawkin Bay, Beach Haven West, and the Natural Marsh Area. The divisions within the survey area facilitated counting and provided better understanding of areas of activity. These areas are described in the previous Definitions section and are shown on the Use Study map, Figure 39. Nine major activities were tallied for each section of the survey area to better understand where the different activities were being performed. These activities include: Bank Fishing, Boat Fishing, Boating, Shellfishing, Bathing, Sailboating, Water Skiing, Hunting and Trapping, with all other activities listed under an Others column.

All survey flights followed the shoreline within the survey area at an average altitude of 500 feet. A single pass through the survey area was generally the rule. Deviations from the flight plan sometimes became necessary to more accurately count large numbers of boats or persons, to clarify the type of activity being performed, or to located waterfowl hunters. Altitude, ranging from 200 to 700 feet, was influenced by visibility and areas of high population density.

Attempts were made to reschedule those flights cancelled because of adverse weather conditions. Counts on foul weather days, if possible, would understandably lower the man-days estimates. Corrections for these cancelled flights on bad weathers were not made. Some cancelled flights could not be rescheduled and were lost for the month.

Boat counts were recorded on the field data sheets for the following activities: boat fishing, boating, shellfishing and sail boating. Actual head counts of people were taken for bank fishing, bathing, water skiing, hunting and trapping. The average number of persons per boat was determined by month through the bag and creel survey data.

Weekday means and weekend-holiday means of man-days of activity were computed by area and activity. These means were expanded according to the number of weekdays and weekend days/holidays in that particular month to determine a monthly estimate. Monthly estimates were computed for each activity in each of the eight sectors of the study area.

II. BAG AND CREEL SURVEY

To estimate the resource harvest per user-group, bag and creel surveys were conducted. Bank and boat fishermen, shellfishermen, hunters, and trappers were personally interviewed to determine the average catch per unit effort for each user-group.

Three bag and creel surveys were scheduled weekly coinciding with the three aerial survey days. One of the two weekday survey, was allocated to bank fishermen, the other to boat fishermen. The weekend survey was alternately scheduled for bank and boat fishermen. During hunting season, one survey day each week was reserved for hunters. The type of survey for each day was randomly chosen. During periods of minimal activity within the study area, such as the winter months, a bag and creel survey would include all user-groups as well as expenditures of those user-groups.

In conducting a bag and creel survey, the field worker visited the known access sites throughout the entire area during the day long survey. Transportation was by automobile. During the summer months, two interviewers were sometimes utilized, each covering half of the survey area.

In addition, one Boat by Boat Survey was scheduled weekly to obtain incomplete trip data from boat fishermen, clammers and hunters who might otherwise be missed during surveys by automobile. The number of Boat by Boat Surveys was determined by weather conditions and boat availability at the Laboratory.

For each Bag and Creel Survey, the field worker interviewed as many people as possible during the course of the day. Only those persons engaged in their activity for a minimum of one hour were counted. This time of one hour was arbitrarily considered the minimum angler or hunter trip to represent a true catch per effort ratio.

The following data were obtained during a bag and creel survey: number of persons in the party, hours engaged in the activity per person, how many hours each individual planned to remain participating in that activity, and catch or harvest by number of each species. Bank fishermen were usually recorded singularly, while boat fishermen at access areas at the end of their trip were interviewed as a group. The number of anglers per boat was recorded and averaged monthly. These data were used to expand the boat counts taken during aerial surveys to arrive at estimates of total persons engaged in boat fishing, boating, and sailboating. The average number of clammers per boat was determined from data taken on Boat by Boat Surveys.

Data derived from Bag and Creel Surveys were summarized monthly. Harvest per effort for hunters and clammers and catch per effort for fishermen were determined from the above described data. Total harvest and catch estimates were calculated by integrating data from aerial surveys and bag and creel survey.

III. EXPENDITURE SURVEY

Expenditure survey data were used to estimate average expenditures of the major user-groups both on a per trip basis and for the year. Originally, expenditure data were collected during bag and creel surveys from one out of every four persons interviewed by the field worker. During the summer months, one survey day per week was randomly chosen for collecting expenditure data only. For the twelve month study period, an expenditure survey was scheduled weekly throughout most of the year.

Data were collected on the following expenditures: bait, boat gas and oil, equipment rental, food, lodging, equipment cost and age, number of trips annually, miles traveled, and any miscellaneous fees. Food and lodging costs were taken for the day only. For example, if a bank fisherman were paying for lodging by the week, one-seventh of this dollar figure was entered on the field data sheets for that day. To estimate the daily value of equipment, the person interviewed was asked to estimate the original cost of his equipment present, the average age of the equipment, and the number of times a year he uses the equipment present for the activity in which he was engaged. The original equipment cost was divided by the product of equipment age and number of trips annually to estimate equipment cost for that day's usage. The round trip mileage for using the estuary was multiplied by the appropriate number of cents per mile for the time period in which the activity took place. During the eight month survey from July 1973 to February 1974, five cents per mile was multiplied by the round trip mileage to estimate car traveling expenses (1970 National Survey of Fishing and Hunting, Bureau of Sport Fisheries and Wildlife, Department of the Interior). For the twelve month survey, June 1974 to May 1975, a figure of twelve cents per mile was used (Federal Government allowance for employees' traveling expenses).

Expenditures data were summarized monthly to give expenditure means for expense categories, value of equipment, and miles traveled. These means were subsequently multiplied by user-group estimates from the aerial surveys to estimate total expenditures for the different user-groups.

IV. RESIDENCE SURVEY

An additional segment was added to the Use Study for the twelve month period, June 1974 to May 1975. This new survey was to determine the County or State of residence of those persons utilizing the survey area.

If the person were from out of State, that particular State was recorded. The yearly percentages of persons residing in Pennsylvania, New York and the individual Counties of New Jersey who traveled to the Manahawkin Bay - Little Egg Harbor Survey area either for recreational or commercial reasons were computed. People were interviewed for County or State residence during both the bag and creel survey and the expenditure survey.

RESULTS

I. AERIAL SURVEY

Seventy-two percent (72%) of all flights scheduled during the twenty months of sampling were completed. Fifty-three flights were cancelled due to inclement weather conditions. If it had been possible to obtain a count of persons using the study area on bad weather days, monthly estimates would understandably be lowered. As stated in the methods section, monthly estimates, as reported, of total man-days of activity are expected to be lower than the actual number since those persons using the study area during early morning and late day or night hours are missed altogether.

Below are listed the numbers of flights scheduled and completed during the twenty months of field sampling.

Date	Flights Scheduled	Flights Completed Weekend/Holiday	+	Weekday	Totals
July '73	14	4	+	6	10
Aug. '73	14	3	+	6	9
Sept. '73	13	5	+	8	13
Oct. '73	13	4	+	8	12
Nov. '73	12	4	+	5	9
Dec. '73	13	2	+	7	9
Jan. '74	9	3	+	3	6
Feb. '74	8	3	+	1	4
Totals	96				72

Seventy-five per cent (75%) of ninety-six scheduled flights were completed during the eight month study of the Manahawkin Bay - Little Egg Harbor System.

Date	Flights Scheduled	Flights Completed Weekend/Holiday	+	Weekday	Totals
June '74	9	1	+	5	6
July '74	14	2	+	9	11
Aug. '74	12	2	+	6	8
Sept. '74	13	3	+	4	7
Oct. '74	5 (1/2 month sched.)	2	+	1	3
Jan. '75	6	1	+	3	4
Feb. '75	8	2	+	5	7
Mar. '75	8	4	+	3	7
Apr. '75	9	2	+	5	7
May '75	10	1	+	4	5
Totals	94				65

Sixty-nine percent (69%) of ninety-four scheduled flights were completed during the twelve month study of the Manahawkin Bay - Little Egg Harbor System.

In summation, the two time periods combined yield the following data:

	Flights Scheduled	Flights Completed	Percentage
	96	72	75
	94	65	69
Totals	190	137	72%

Use Estimates

Results of the two study periods will first be presented separately. A comparison of the findings will then be made attempting to combine the twenty months of data into yearly estimates of total man-days of activity.

Ia. Eight Month Study -- July 1973 to February 1974

The following use estimates for Manahawkin Bay - Little Egg Harbor are taken from Nacote Creek Research Station, Miscellaneous Report No. 14M, and are reproduced in their entirety.

During the eight month study period, a total of 158,269 man-days of activity were spent on the study area (Table 189). Boat fishing was the most heavily engaged in activity in the study area and represented 42.25% of all activity in the study area.

Even this figure, however, is considered minimal since a substantial portion of boaters, the second largest single category, were actually fishermen under way from one fishing ground to another, or between fishing grounds and a landing.

Following boat fishing in popularity were boating (22.51%), shell fishing (11.75%), sailboating (10.90%), bathing (5.56%), bank fishing (4.91%), others (1.11%), water skiing (0.68%) and hunting (0.34%) in that order.

The warm summer months proved to put the greatest activity demands upon the study area. July (36.44%) and August (39.00%) combined to account for over 75% of all activity during the eight month study period. After the summer months, user activity declined steadily for the remainder of the study period. Tables 190 through 197 give estimated man-days of activity figures by area and activity for each month of the survey, while Table 198 gives the total estimated man-days of activity for the entire study period, also broken down by area and activity. These tables also present figures for that percent of user-group activity that occurs in each area section (this figure appears as the upper percentage figure on the charts and is totalled across) and for that percent of total sector activity that each user-group represents (this figure appears as the lower percentage figure and is totalled down).

East Little Egg Harbor accommodated the greatest activity demands of the study are (27.55%). This is due mainly to the fact that it contained the greatest percentage of boat fishermen and boaters, the two most popular user-groups. This section of the study area also accounted for the greatest amount of user activity in the category of others. The majority of the fishing done in this portion of the bay was by private boats with fluke being the most sought after and successfully caught species; weakfish, striped bass and bluefish were also taken.

West Little Egg Harbor ranked second in overall activity and accounted for the greatest percentage of shell fishermen (42.77%) and bank fishermen (25.42%) and the second greatest percentage of boat fishermen and boaters.

East Lower Manahawkin Bay ranked third in overall activity and accounted for the greatest percentage of sailboaters (32.28%) and bathers (43.89%) and the second greatest percentage of bank fishermen.

West Upper Manahawkin Bay had the lowest percentage of overall activity, but had the second highest percentage of hunter activity. It also probably had the greatest number of boat rentals for fishing and crabbing, and undoubtedly produced the best crabbing in the study area.

West Lower Manahawkin Bay accounted for only 14.03% of all activity in the study area but it contained the sub-sections of Beach Haven West and the Natural Marsh, and therefore deserves some special comment in this portion of the report. The following table shows the total man-days of activity estimates for the Beach Haven West and Natural Marsh sub-sections.

	Bank Fishing	Boat Fishing	Boating	Sail Boating	Bathing	Hunting	Others	Total
Beach Haven West	89	17	1537	32	554	--	27	2256
Natural Marsh	32	76	21	--	--	71	3	203
Totals	121	93	1558	32	554	71	30	2459

It is noticed from the above chart that Beach Haven West accommodated over ten times the total amount of activity of the Natural Marsh. This figure may, however, be very misleading. Over 68% of the activity occurring in Beach Haven West was boating. It does not matter whether these boaters were on their way to go pleasure boating, boat fishing, or water skiing, it seems obvious that they were on their way somewhere else to enjoy their end activity. In this regard, the lagoon community was acting only as a docking facility. It is also probable that the sailboats encountered within the lagoon community were also in transit to the bay to fully realize the enjoyment of sailing, although moving under sail within the lagoon complex must test their skills to the utmost.

The Natural Marsh sub-section has a higher percentage of activity for only two activity categories. These are boat fishing, which makes up 0.70% of the total boat fishing of West Lower Manahawkin Bay, and hunters which make up 27.20% of all area 1 hunters and 13.20% of all hunters within the study area.

Tables 199, 200 and 201 show the distribution of bank fishing, boat fishing, and boating, respectively, for the eight month study period by sector and month.

Ib. Twelve Month Study - June 1974 to May 1975

It is estimated that 230,326 man-days of activity were spent in the study area during ten months of aerial surveys. Since no aerial surveys were conducted during November 1974 and December 1974, a yearly estimate of total man-days of activity is not presented in this section for the twelve month study period.

Table 202 presents the estimated total man-days of activity by activity category and month.

Tables 203 through 212 present the monthly estimates of man-days of activity for those ten months in which aerial surveys were conducted.

Boat fishing again accounted for the greatest percentage of activity, 46.56%. The remaining activity categories and their percentages are reported as follows: boating (22.00%), shellfishing (16.75%), bank fishing (6.91%), sail boating (3.68%), bathing (3.34%), others (0.54%), water skiing (0.17%), and hunting (0.05%).

The estimated total man-days of hunting activity, 117 man-days, appears to be a gross underestimate for the study period due to having data for only the month of October.

By month, the summer months of July and August understandably accounted for over sixty percent of the total activity within the study area.

The months sampled and their corresponding percentage of total estimated activity are as follows: January (1.10%), February (0.85%), March (2.42%), April (3.36%), May (4.54%), June (12.60%), July (28.26%), August (31.94%), September (10.13%), and October (4.80%).

East Little Egg Harbor Bay, with the great recreational pressures of boat fishing and boating, accommodated the most activity, 28.90%.

West Little Egg Harbor Bay accommodated 27.35% of the activity during the study period, again, boat fishing (45.61%) predominating the activity. The greatest percentage of shellfishing (49.89%) occurred within this area.

West Lower Manahawkin Bay, including Beach Haven West and the Natural Marsh Area, accounted for 15.41% of all activity, dominated by boat fishing and shellfishing.

The greatest percentage of bank fishermen, 28.32%, was located in West Upper Manahawkin Bay.

East Upper Manahawkin Bay contained the most bathers, 33.65%, within the survey area.

Refer to Table 213 for a complete breakdown of activity by area and activity category. Tables 214 through 216 present the distribution of bank fishing, boat fishing, and boating by area and month for the study period.

A comparison of Beach Haven West and the Natural Marsh Area is given in the following chart:

	Bank Fishing	Boat Fishing	Boating	Sail Boating	Bathing	Hunting	Others	Totals
Beach Haven West	155	187	4051	40	383	--	84	4900
Natural Marsh	151	330	592	4	--	9	69	1155
Totals	306	517	4643	44	383	9	153	6055

Again, the boating estimate of 4,051 for Beach Haven West may be misleading in estimating total activity for that area. It is very likely that many of these boats were in transit from the lagoon community to participate in boat fishing, pleasure boating, or some other activity elsewhere.

Ic. Comparison of Use Estimates for the Two Sampling Periods

Aerial surveys were conducted each month of the eight month study period. During the twelve month study of the same area, aerial surveys were conducted during only ten of the twelve months due to temporary expiration of project funds. Consequently, only six months of the year were sampled twice as shown below:

Month	Estimated Man Days of Activity	Month	Estimated Man Days of Activity	Percent Increase
July '73	57,678	July '74	65,100	+ 12.87
Aug. '73	61,726	Aug. '74	73,559	+ 19.17
Sept. '73	22,029	Sept. '74	23,324	+ 5.88
Oct. '73	7,948	Oct. '74	11,061	+ 39.17
Jan. '74	2,000	Jan. '75	2,532	+ 26.60
Feb. '74	1,308	Feb. '75	1,960	+ 49.85
Totals	152,689		177,536	+ 16.27

For those months which were sampled twice, the twelve month study shows an average percent increase of 16.27% over the eight month study in total man-days of activity.

This percent increase of 16.27% from the first study period to the second was used to estimate those months when no aerial surveys were conducted or the study was not in progress. This was done to provide two twelve-month periods of total man-days of activity, thus giving yearly estimates of total man-days of activity for the two study periods. Yearly estimates were not previously given when each study period was analyzed separately.

Below are listed the data for two estimated yearly totals of man-days of activity.

Month	June 1973 to May 1974 Total Man Days of Activity	June 1974 to May 1975 Total Man Days of Activity
January	2,000	2,532
February	1,308	1,960
March	4,785*	5,564
April	6,656*	7,739
May	8,994*	10,457
June	24,968*	29,030
July	57,678	65,100
August	61,726	73,559
September	22,029	23,324
October	7,948	11,061
November	3,274	3,807*
December	2,306	2,681*
Total	203,672	236,814
Average Month	16,973	19,734

*Estimated using the 16.27% average increase between the two study periods.

Below is a comparison by activity category of estimated man-days of activity for the two study periods showing the totals for those six months which were sampled twice.

	1973-1974* Man-Days of Activity	1974-1975* Man-Days of Activity	Difference in Man-Days
Bank Fishing	7,503	11,997	+ 4,494
Boat Fishing	65,033	81,908	+16,875
Boating	34,319	42,746	+ 8,427
Shellfishing	16,913	25,721	+ 8,808
Sailboating	17,194	7,476	- 9,718
Water Skiing	1,071	357	- 714
Bathing	8,795	6,393	- 2,402
Hunting	114	117	+ 3
Others	1,747	821	- 926
Total	152,689	177,536	+24,847

*Totals for the months of July, August, September, October, January and February only.

The four major activity categories of bank fishing, boat fishing, boating, and shellfishing showed increases in man-days of activity of 60%, 26%, 24% and 52% respectively. These increases account for an additional 38,604 man-days of activity. Major decreases in use estimates occurred in the sailboating and bathing categories, 12,120 man-days of activity. The overall difference in use estimates for the two six month sampling periods shows a net increase of 24,847 man-days of activity when all activity categories are considered.

II. BAG AND CREEL SURVEY

Harvest Estimates

IIa. Eight Month Study - July 1973 to February 1974

The following harvest estimates are taken from Nacote Creek Research Station, Miscellaneous Report No. 14M, and are reproduced below. A total of 1,878 persons were interviewed during the bag and creel surveys for this study period (see Table 217).

Bag and creel interviews, expanded to the extent of the use estimates indicate that over four hundred thousand fish (including crabs), 9.5 million clams, 4.5 million bay scallops and three hundred waterfowl were harvested from the study area during the eight month study period. Estimated total catch, catch composition, and catch per effort statistics on the above mentioned renewable resources are given in Tables 218 through 224.

The boat fisherman accounted for 94.86% of the total estimated fish catch. The highest estimated boat catch occurred in July and decreased every month after that throughout the survey period. Boat fishing catch per effort hit a peak of over four fish per hour in October, but averaged only slightly above 1 fish per hour for the survey period. The blue crab constituted the most readily caught species and comprised 68.21% of the total catch. The fluke was undoubtedly the most sought after fish and was the second most plentiful representative in the fisherman's creel at 13.12% of the catch. Bluefish (9.67%), blowfish (1.48%) and spot (1.37%) comprised the bulk of the remaining catch.

r Blue crabs accounted for the majority (79.36%) of the bank fisherman's catch. Bluefish (6.43%), fluke (4.66%), spot (3.30%), eels (0.97%) and weakfish (0.97%) were also taken with fair success by the bank angler. The highest estimated bank catch occurred in July, and like the boat catch, decreased every month after that throughout the survey period. The best catch per effort occurred in November for the bank fisherman with 1.38 fish per hour. The survey long average was 1.02 fish per hour, slightly lower than that of the boat fisherman. The "others" category of fish taken represented 1.82% of the total combined estimated catch and was mainly comprised of the oyster toadfish, northern searobin, sandbar shark, and smooth dogfish.

The bank fisherman had his highest estimated catch in July, which stands to reason since he also had more man-days of participation in July than any other month. The boat fisherman, on the other hand, had over three thousand more man-days of participation in his sport in August than in July, but recorded a greater catch in July. This was due basically to better fishing (a better catch per effort ratio) and more hours spent on the water in July (a longer average man-day).

The waterfowl harvest estimates given in this report are probably low. The aerial survey flights are scheduled randomly between 10:00 A.M. and 2:00 P.M. so that they occur during the peak activity period (Briggs, 1962). There is no doubt that hunters frequently entered and left the study area before and after the peak activity period, or to be more precise, before and after the aerial survey flight. Waterfowl hunters increase their success by being inconspicuous and staying out of sight of their prey. Thus, the skillful hunter may also have escaped observation by aerial survey, and further lowered the estimated hunter activity and harvest figures. Hunter interviews were also found difficullt to obtain and low numbers of interviews could also cause inaccuracies in the survey.

An estimated total waterfowl harvest of 306 birds was recorded on the survey area during the 1973 hunting season with a hunter success ratio of 0.11 birds per hour. The black duck (38.56%) and bufflehead (29.74%) comprised the bulk of the hunter's bag (Table 223).

Shellfishing was the third most heavily engaged in activity within the study area during the eight month survey, and during the winter months of December, January, and February, the most heavily engaged in activity. Sport and commercial shellfishermen harvested over 14.3 million shellfish during that period. Shellfishing is the only year-round, heavily engaged in activity in the study area, has high recreational and commercial interests, produces a highly valuable commodity, and costs the shellfishermen an estimated ninety-six thousand dollars to engage in their activity for eight months. This must be ranked as being among the top two or three more important human activities within the study area.

Clams are harvested on a year-round basis. The highest harvest levels occur in the summer months when recreational and part-time commercial clammers swell the ranks. The highest catch per effort levels occur during the winter months when only the full time experienced commercial clammers are plying their trade. Scallops are harvested only during the open season which extends into the three cold weather months of November, December, and January.

During this period, an estimated 4,658,326 bay scallops were harvested at an outstanding estimated catch per effort rate of over 776 scallops per hour.

IIb. Twelve Month Study - June 1974 to May 1975

Data from over twenty-five hundred interviews (see Table 225) during bag and creel surveys were expanded to estimate total harvest for the Manahawkin Bay - Little Egg Harbor System. Total estimated bank fishing, boat fishing, shellfishing, and hunter harvest are presented in Tables 226 through 232 for those ten months in which aerial surveys were conducted. It is estimated that over 450,000 fish (including crabs), and over 19 million clams, were harvested within the survey area during a ten month period. Hunter harvest figures are suspect due to the small amount of data taken only during the month of October 1974. This will be elaborated upon later in the report.

Bank fishermen caught an estimated 46,594 fish (see Table 226), 89.60% of which were blue claw crabs. Of the finfish species caught by bank fishermen, bluefish 3.90%, winter flounder 2.97%, and eels 0.82%, comprised the bulk of the catch. Less than 3.00% of the estimated total catch of bank fishermen was composed of species other than those mentioned above. The summer months of July and August accounted for over sixty percent of the ten month total catch, again comprised mostly of blue claw crabs.

Catch per effort figures for bank fishermen given in Table 230 show the greatest success in August and September, 1.79 and 1.77 fish (including crabs) per hour. The yearly catch per effort for bank fishermen was 1.32 fish per hour, greatly influenced by the crabbing success of the summer months.

Boat fishermen caught an estimated 412,287 fish, including 242,651 blue claw crabs for the ten months sampled (Table 227). The blue crab represents 58.85% of the total estimated catch. Following crabs were: fluke, 79,450 for 19.27%; bluefish, 31,112 for 7.55%; black sea bass, 21,590 for 5.24%; winter flounder, 15,222 for 3.69%; and weakfish, 11,390 for 2.76%. The total catch is based on the total estimated man-days for boat fishermen. It has been mentioned that a good percentage of those counted in the user-group, boating, were actually boat fishermen in transit. Boat fishing man-days of activity for the ten month period are estimated at 107,239 man-days. Total estimated catch is based on this figure. The boating category accounts for an estimated 50,682 man-days of activity. What percentage of these boaters were actually boat fishermen is not known. Therefore, the total estimated boat fishing catch is a low estimate. Catch per effort figures for boat fishermen (see Table 229) are highest for September, 1.66, and October, 1.93, when bluefish, black sea bass, fluke, and weakfish dominated the catch. The ten month catch per effort average for boat fishermen was 1.19 fish (including crabs) per hour.

Table 228 shows the total estimated combined fishing catch composition for bank and boat fishermen for the ten month period. Of the total estimated catch, 458,881 fish and crabs, boat fishermen accounted for 89.85% of the catch, compared to 10.15% for bank fishermen. Of the combined man-days of activity for bank and boat fishermen, 123,159 man-days, bank fishermen accounted for only 12.93% of the activity, boat fishermen, 87.07%. Catch per effort comparisons show bank fishermen having slightly better success than boat fishermen, 1.32 to 1.19. Species listed in the "others" include: sharks, sea robins, and oyster crackers.

Only thirty-two hunters were interviewed during the survey period, hunter activity being estimated at 117 man-days during the month of October 1974. Since no aerial surveys were conducted during November 1974 and December 1974, no estimate of total man-days of hunting activity is given. Table 230 represents the actual and estimated data for hunter harvest based on hunter interviews. Species harvested include the green winged teal, mallard, black duck, and blue winged teal (see Table 231).

Division owned land in the Great Bay Boulevard Area was surveyed by Game Biologists for waterfowl harvest during the 1974-1975 waterfowl hunting season (see Wetlands Ecology, Waterfowl Harvest, Project No. W-53-R-3, Job No. I-D). Only about half of the Great Bay Boulevard Area surveyed under the above project is included in the Manahawkin Bay-Little Egg Harbor survey area, the marshland north of the boulevard. For the entire Great Bay Boulevard Area, hunters spent 2,129 days harvesting 854 ducks and 46 geese. Rail hunters harvested 524 clapper rails and 7 sora rails during an additional 221 days of hunter activity in that same area.

Clamming total harvest estimates based on the ten months of field data project a total of 19,177,104 hard clams taken from the Manahawkin Bay-Little Egg Harbor System (see Table 232). Clamming harvest was estimated for the day for each clammer interviewed and expanded based on the estimated man-days of clamming activity for each month. Catch per effort figures show the number of clams harvested per hour based on interview data. Clamming activity was highest during the month of July, 9,878 man-days of activity, but showed the lowest catch per effort, 44.43 clams per hour. Both the commercial and recreational clamming data are combined in estimating catch per effort and total harvest. Over three million clams were harvested during the months of August and September, reflecting good catch per effort and man-days of activity figures. The best catch per effort occurred in the month of October when 205.67 clams were harvested per hour.

IIc. Comparison of Harvest Estimates for the Two Sampling Periods

For the six months of the year which were sampled twice and have total harvest estimates, comparisons are given in Tables 233 through 235. Bank fishing, boat fishing, and clamming harvest estimates are presented, as well as catch per effort figures. Hunter harvests were not compared due to insufficient data. Catch per man-day, as opposed to catch per man-hour, estimates are used throughout this section of comparisons of total harvest estimates.

Table 233 compares the estimated bank fishing catch by species for the two time periods: July, August, September, October 1973, January, February 1974 against July, August, September, October 1974, January, February 1975. Total estimated catch of Manahawkin Bay-Little Egg Harbor shows an increase of 79% from the first sample to the second a year later. However, total man-days of bank fishing activity increased 60% for the same time periods, from 7,503 to 11,997 man-days. When total catches are compared for an equal number of man-days of activity, the estimated bank fishing catches show an increase of 12%. The catch per man-day for the second time period shows an increase from 3.00 to 3.35 fish (including crabs) per man-day.

Boat fishing harvest comparisons show a decrease of 24% from the first sampling period to the second. Adjusting total harvest estimates for equal numbers of man-days of boat fishing activity, a comparison shows an even larger decrease in number of fish and crabs of 40%. Table 234 shows the comparison of harvest estimates by species. The bulk of the estimated harvest decrease is due to a substantial reduction in the blue claw crab catch from 289,052 to 187,193 crabs. Comparing estimated boat fishing catches for the two sampling periods excluding the crab catch figures reduces the percent difference in half from -40% to -20%. The closing or significnt reduction in business of a large boat livery could drastically reduce the catch of blue claw crabs. Also, reduced sampling at such boat liveries would also produce such a decrease in catch estimates. Catch per effort figures for the two sampling periods also shows a decrease in numbers of fish (including crabs) per man-day of boat fishing activity (see Table 234). Comparing catch per effort for total harvest estimates, there was a decrase from 6.47 fish per man-day for the first sampling period 1973-1974 to 3.90 fish per man-day for the second sampling period 1974-1975. Catch per effort figures for finfish species only show a decrease from 2.02 to 1.62 fish per man-day.

Hard clam harvest comparisons are presented in Table 235. For an equal number of man-days for each sampling period, there occurred a 9% decrease in the total number of clams harvested. Total man-days of clamming activity increased 63% from the first sampling period, 1973-1974, to the second sampling period, 1974-1975. Total catch estimates increased only 49%. Adjusting either total catch for an equal number of man-days of activity shows the 9% decrease in total number of hard clams harvested.

III. EXPENDITURE SURVEY

Expenditure Estimates

IIIa. Eight Month Study - July 1973 to February 1974

Over sixteen hundred persons were interviewed for expenditure data during this sampling period (see Table 236). Tables 237 through 240 present the estimated expenditures of bank fishermen, boat fishermen, shellfishermen, hunters, bathers, and sailboaters. The following text analyzes these data and is taken from Nacote Creek Research Station. Miscellaneous Report 14M.

An estimated total of 74,632 angler days were spent on the study area with an accompanying estimated $738,921.27 expenditure on the part of the anglers involved. This works out to be an expenditure of $9.90 per angler trip, including equipment costs. The estimated 446,754 fish (including crabs) taken by anglers over the survey period cost an average of $1.65 per fish.

Boat fishermen spent an estimated $697,987.66 on an estimated 66,861 angler-trips for an average of $10.44 per trip or $1.65 per fish. Bank fishermen spent an estimated $40,933.61 on an estimated 7,771 angler-trips for an average of $5.27 per trip or $1.78 per fish.

Shellfishermen spent an estimated 18,603 man-days on the bay at an estimated cost to the shellfishermen of $96,301.28 or approximately $5.18 per trip. An estimated 538 hunter-days were spent in the study area at an estimated hunter cost of $8,676.35 or $16.13 per trip. Bather man-days were estimated at 8,795 with an accompanying expenditure of $29,204.15 for an estimated $3.32 expenditure per trip. Sail boaters enjoyed an estimated 17,250 man-days engaged at their sport at an estimated ccost of $300,787.97 or $17.44 per trip.

Per trip expenses ranged from a high for sailboaters of $17.44 in order through hunters ($16.13), boat fishermen ($10.44), bank fishermen ($5.27) and shellfishermen ($5.18) to a low of $3.32 fo bathers.

Total estimated expenditure for all categories surveyed for expenditures for the eight month survey period were $1,173,891.02.

IIIb. Twelve Month Study - June 1974 to May 1975

Over twenty-four hundred persons were interviewed for expenditure data during this sampling period (see Table 241). Tables 242 through 245 present expenditure breakdowns for the major activity groups.

Bank fishermen spent an estimated $116,464.95 for the ten month period, June 1974 to May 1975, excluding November and December 1974 (see Table 242). The average per trip expenditure of $7.33 is broken down in the following manner: $0.59 for bait, $0.62 for food, $0.48 for lodging, $0.40 for equipment, and $5.21 for traveling expenses. Other expenses include equipment rental and miscellaneous fees, a total of $0.04 per trip. The estimated total harvest for bank fishermen for this sampling period was 46,594 fish (including crabs). The cost per fish estimate is $2.50.

Boat fishermen during this same time period spent an estimated $1,630,680.52 to harvest an estimated 412,287 fish (including crabs). This comes to $3.96 per fish. Per trip expenditures for a boat fisherman are estimated at $15.21: $0.66 for bait, $0.54 for boat gas and oil, $2.05 for equipment rentals, $0.29 for food, $0.82 for lodging, $6.65 for equipment, $4.18 for traveling expenses and $0.02 for miscellaneous fees. Estimated total expenditures for boat fishermen are presented by month in Table 243.

Estimated total expenditures for shellfishermen, Table 244, are $209,924.95 for the above sampling period. The estimated per trip expenditure of $6.23 is comprised of: $1.21 for boat gas and oil, $0.29 for food, $0.40 for related fees, $1.81 for equipment, and $2.53 for traveling expenses. Clamming expenditure data includes both the year long commercial clammer and the seasonal recreational clammer. It would be a fair assumption that the per trip expenditure for a commercial clammer would be less than the estimate of $6.23 due to reduced traveling expenses and equipment value, whereas the per trip expenditure of a recreational clammer would be more.

Sailboating expenditures are estimated at $23.24 per man-day of activity based on eight-five interviews (see Table 245). Of this estimated daily expense, $0.95 was for equipment rental, $2.39 for food, $3.27 for lodging, $0.44 for related fees, $5.98 for equipment, and $10.21 for traveling expenses. Total estimated expenditures for sailboaters for the four months of June, July, August, and September 1974 are $186,962.39.

One hundred and eighty-six bathers were interviewed for expenditure data. The bathing expenditure estimate of $8.15 per man-day of activity is broken down into the following categories: $3.41 for traveling expenses, $3.00 for lodging, $1.69 for food, and $0.04 for miscellaneous fees.

Total expenditures for the activity groups interviewed within the survey area for a ten month period are estimated at $2,206,033.04. Expenditure data were not tabulated for those persons in the activity categories of boating, water skiing, and the "others" category. Hunter expenditure estimates are not given due to insufficient data.

IIIc. Comparison of Cost Estimates for the Two Sampling Periods

There is an increase in per trip expenditure estimates for all the major activity categories sampled during the two study periods.

	8 month study July '73 - Feb. '74	12 month study June '74 - May '75
Bank fishermen	$ 5.27	$ 7.33
Boat fishermen	$10.44	$15.21
Shellfishermen	$ 5.18	$ 6.23
Sailboaters	$17.44	$23.24
Bathers	$ 3.32	$ 8.15

The per trip expenditure estimates for the above activity categories are broken down below into separate per trip expenses to better understand where expenditure estimates have increased. The most obvious increase is in traveling expenses where the per mile cost estimate has gone from $.05 for the first sampling period to $.12 for the second sampling period. Bait, equipment, and food expenses may have increased from one year to the next.

Bank fishing per trip expenditures increased from $5.27 to $7.33 due largely to increased travel costs:

	July '73 to Feb. '74	June '74 to May '75
Bait	$0.41	$0.59
Equipment rental	0.01	0.02
Food	0.76	0.62
Lodging	1.26	0.48
Fees	0.02	0.01
Equipment	0.67	0.40
Mileage	2.14 (40 miles)	5.21 (44 miles)
	$5.27	$7.33

Boat fishermen's per trip expenditure estimates went from $10.44 to $15.21, again due largely to travel expenses and also due somewhat to equipment cost estimates:

	July '73 to Feb. '74	June '74 to May '75
Bait	$ 0.45	$ 0.66
Boat gas and oil	0.46	0.54
Equipment rental	1.82	2.05
Food	0.22	0.29
Lodging	0.41	0.82
Fees	0.05	0.02
Equipment	5.74	6.65
Mileage	1.29 (30 miles)	4.18 (35 miles)
	$10.44	$15.21

Clammers' per trip expenditures increased from $5.18 to $6.23, travel cost estimates increasing substantially while equipment costs decreased somewhat:

	July '73 to Feb. '74	June '74 to May '75
Boat gas & oil	$1.69	$1.21
Food	0.31	0.29
Fees	0.05	0.40
Equipment	2.53	1.80
Mileage	0.60 (12 miles)	2.53 (21 miles)
	$5.18	$6.23

Sailboating again proved to be the most expensive activity with per trip expenditure estimates increasing from $17.44 to $23.24, even though equipment cost estimates were nearly half as much:

	July '73 to Feb. '74	June '74 to May '75
Equipment rental	$ 1.31	$ 0.95
Food	0.54	2.39
Lodging	1.22	3.27
Fees	0.04	0.44
Equipment	11.52	5.98
Mileage	2.81 (56 miles)	$10.21 (85 miles)
	$17.44	$23.24

Bathers' per trip expenditures increased in every major expense category. The per trip expenditure estimates of $3.32 and $8.15 are explained below:

	July '73 to Feb. '74	June '74 to May '75
Food	$0.39	$1.69
Lodging	1.86	3.00
Miscellaneous	0.17	0.05
Mileage	0.90 (18 miles)	3.41 (28 miles)
	$3.32	$8.15

Hunters' per trip expenditure estimates are not compared due to insufficient data for the second sampling period, June 1974 to May 1975.

IV. RESIDENCE SURVEY

Over twenty-five hundred persons during the survey year, June 1974 to May 1975, were asked their County and/or State of residence, during either the bag and creel or expenditure surveys. The yearly summarization of these data appears in Table 246. New Jersey residents accounted for 70.75% of sportsmen using the Manahawkin Bay-Little Egg Harbor System, engaging in either bank fishing, boat fishing, or clamming throughout the year. Pennsylvania residents accounted for 24.19% of the total; New York, 4.62%; and other States, 0.44%. Over half the total number of persons interviewed were bank fishermen.

Tables 247 through 250 give a seasonal breakdown of the residence of persons using the survey area during. Four three-month intervals.

The percentages of those persons residing in the separate counties within the state of New Jersey on interview data are:

County	Percentage
Ocean	39.86
Burlington	19.91
Camden	13.72
Mercer	5.29
Essex	3.32
Bergen	3.21
Hunterdon	1.97
Union	1.86
Somerset	1.69
Gloucester	1.63
Middlesex	1.57
Morris	1.52
Hudson	1.41
Monmouth	0.73
Cumberland	0.56
Atlantic	0.28
Others	2.47
Total	100.00%

SUMMARY

The Use Study of the Manahawkin Bay-Little Egg Harbor System is an attempt to estimate the total man-days of the major estuarine activities, thee total resource harvest of fishermen, shellfishermen, and hunters, and the total expenditures of the major activities occurring within the study area.

Aerial surveys were designed to determine the numbers of persons engaged in the major activities of: bank fishing, boat fishing, shellfishing, boating, sailboating, water skiing, bathing, and hunting. These separate activities were also tabulated by eight geographical areas to better develop a total use picture of the study area.

During bag and creel surveys, data were obtained through personnel interviews to estimate the total resource harvest, as well as catch per effort figures, for the major activity categories of bank fishing, boat fishing, shellfishing, and hunting.

Expenditure data were also obtained through personal interviews to estimate the total expense and per trip expense of the major activity categories.

A residence survey was conducted to determine the county and/or state of residence of those persons participating in the estuarine related activities.

This report presents the above estimates for two separate sampling periods. Initially, the Use Study of Manahawkin Bay-Little Egg Harbor was conducted from July 1973 to February 1974 (hereafter referred to as the first sampling period). The study was resumed in June 1974 and continued to May 1975 (the second sampling period). Estimates of total activity, resource harvest,

and expenditures are presented for each sampling period. Activity estimates, catch per effort estimates, and per trip expenditure estimates were then compared for the two sampling periods.

Aerial survey data show an increase of 16.27% in estimated man-days of activity from the first sampling period to the second. Yearly estimates of total man days of activity are 203,672 man-days for June 1973 to May 1974 and 236,814 man-days for the time period, June 1974 to May 1975. The four major activity categories of bank fishing, boat fishing, boating, and shellfishing showed increases in man-days of activity of 60%, 26%, 24% and 52% respectively, whereas, major decreases in use estimates occurred in the sailboating and bathing categories.

Bank fishing resource harvest estimates show an increase of 79% from the first sampling period to the second. The catch per effort increased from 3.00 to 3.35 fish (including crabs) per man-day, and the total bank fishing activity increased 60%. Boat fishing harvest comparisons show a decrease of 24% from the first sampling period to the second, due mostly to a reduction in the blue claw crab catch. Catch per effort estimates decreased from 6.47 to 3.90 fish (including crabs) per man-day. Hard clam harvest estimates decreased 9% when comparing an equal number of man-days of activity. Over nineteen million clams were harvested for the ten month period, June 1974 to May 1975, excluding November and December 1974. An estimated total waterfowl harvest of 306 birdds was recorded on the survey area during the 1973 hunting season with a hunter success ratio of 0.11 birds per hour.

Bank fishermen's per trip expenditures increased from $5.27 to $7.33, boat fishermen from $10.44 to $15.21, shellfishermen from $5.18 to $6.23, sailboaters from $17.44 to $23.24, and bathers from $3.32 to $8.15, all due mostly to increased traveling costs.

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